Problem Set #9

① (a) $K = \frac{[O_2]^3}{[O_3]^2}$ homogeneous

(b) $K = \frac{1}{[Cl_2]^2}$ heterogeneous

(c) $K = \frac{[C_2H_6]^2[O_2]}{[C_2H_4]^2[H_2O]^2}$ homogeneous

(d) $K = \frac{[Cl_2]^2}{[HCl]^4[O_2]}$ heterogeneous

② $[CO] = \frac{0.170\ mol}{2.00\ L} = 0.0850\ M$ $[CH_3OH] = \frac{0.0406\ mol}{2.00\ L} = 0.0203 M$

$[H_2] = \frac{0.302\ mol}{2.00\ L}$

$K = \frac{[CH_3OH]}{[CO][H_2]^2} = \frac{(0.0203)}{(0.0850)(0.151)^2} = 10.5$

$K > 1$ Forward Rx (products) favored.

③ ~~$2(NO \rightleftharpoons \frac{1}{2}N_2 + \frac{1}{2}O_2)$~~ $K_1 = \left(\frac{1}{4.8\times10^{-10}}\right)^2$

$2NO_2 \rightleftharpoons$ ~~$2NO$~~ $+ O_2$ $K_2 = 1.1\times10^{-5}$

$2NO_2 \rightleftharpoons N_2 + 2O_2$

$K_{overall} = K_1 \times K_2 = \left(\frac{1}{4.8\times10^{-10}}\right)^2 \times (1.1\times10^{-5}) = 4.8\times10^{13}$

④ Initial concentrations of H_2 & Br_2

H_2: $1.374\ g\ H_2 \left(\frac{1\ mol\ H_2}{2.02\ g\ H_2}\right) = 0.680\ mol\ H_2$

$$M = \frac{0.680\ mol}{2.50\ L} = 0.272\ M$$

Br_2: $70.31\ g\ Br_2 \left(\frac{1\ mol\ Br_2}{159.8\ g\ Br_2}\right) = 0.440\ mol\ Br_2$

$$M = \frac{0.440\ mol}{2.50\ L} = 0.176\ M$$

Equilibrium concentration of H_2:

$0.566\ g\ H_2 \left(\frac{1\ mol\ H_2}{2.02\ g\ H_2}\right) = 0.280\ mol\ H_2$

$$M = \frac{0.280\ mol}{2.50\ L} = 0.112\ M$$

	$[Br_2]$	$[H_2]$	$[HBr]$	
Initial	0.176	0.272	0	
Change	−0.160	−0.160	+0.320	
Equil	0.016	0.112	0.320	← Equilibrium concentrations

$$K = \frac{[HBr]^2}{[Br_2][H_2]} = \frac{(0.320)^2}{(0.016)(0.112)} = \underline{57}$$

Equilibrium concentrations: $[Br_2] = 0.016\ M$

$[H_2] = 0.112\ M$

$[HBr] = 0.320\ M$

(5) $Q = \frac{[CO][Cl_2]}{[COCl_2]} = \frac{(3.3\times10^{-6})(6.62\times10^{-6})}{(2.00\times10^{-3})} = 1.1\times10^{-8}$

$Q >> K$ ($K = 2.19\times10^{-10}$) Rx runs left

(6)

$K = \frac{[BrCl]^2}{[Br_2][Cl_2]} = 7.0$

	$[Br_2]$	$[Cl_2]$	$[BrCl]$
I	0.25	0.25	0
C	$-x$	$-x$	$+2x$
E	$0.25-x$	$0.25-x$	$2x$

$\frac{(2x)^2}{(0.25-x)(0.25-x)} = 7.0$

$\frac{2x}{0.25-x} = \sqrt{7.0}$

$4.6x = 0.66$

$x = 0.14\ M$

$[Br_2] = [Cl_2] = 0.25\ M - 0.14\ M = 0.11\ M$

$[BrCl] = 2(0.14\ M) = 0.28\ M$

equilibrium concentrations

(7) The following reaction is exothermic: $2\ Cl_2\ (g) + C\ (s) \leftrightarrow CCl_4\ (g) + q$

I. Predict the effect (shift right, shift left, or no effect) of the following:

(a) Adding more CCl_4 to the reaction mixture: shifts left

(b) Increasing the temperature of the reaction mixture: shifts left

(c) Adding more C to the reaction mixture: no effect

(d) Adding more Cl_2 to the reaction mixture: shifts right

(e) Decreasing the volume of the reaction mixture: shifts right

(f) Adding a catalyst to the reaction mixture: no effect

II. Will the equilibrium constant of the reaction increase or decrease if the temperature is increased?

K decreases